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NASA TECH BRIEF

Lewis Research Center

Computer Program Calculates Quasi-One-Dimensional Flow Across Face Seals and Narrow Slots

The Problem:

A computer program was needed that would calculate the properties of compressible fluid flow with friction across shaft face seals and narrow slots.

The Solution:

A program, QUASC, to calculate mass and volume leakage across a seal; mean friction factor; force; center of pressure; and distributions of pressure, temperature, density, friction parameter, velocity, and Mach number across a seal for both laminar and turbulent flow regimes and for choked and subsonic flow.

How It's Done:

The program is based on a mathematical model for face seals, which consist of two parallel, coaxial, circular rings separated by a very narrow gap. A pressure difference exists between the rings' inner and outer radii. The cavities on either side (i.d. and o.d.) of the sealing dam are assumed to be constant pressure reservoirs. The flow is assumed to be entirely radial. The effects of rotation of the two seal faces are negligible for most applications. Since the radial distance across the seal is very small compared to the mean radius of the rings (i.d./o.d.= 0.98), the area expansion is negligible.

This computer program has proved useful in seal design, where much of the physical information of interest is difficult to determine experimentally. A mathematical model tested on a computer can generate this needed information. The model on which QUASC is based has been shown to be a good model for conventional face seals which are pressure (force) balanced and for seals with self-acting lift pads.

Some of the physical parameters of interest in designing a seal are the leakage, the pressure distribution across the seal, and the opening (separating) force. These and other parameters are determined by the program for specified seal geometries (flow length and gap).

In general, QUASC performs the following operations in analyzing the flow across a seal: reads the input data and checks that these data are consistent; determines the minimum film thickness for choked flow; and then, for each given film thickness, determines which type of flow is associated with this film thickness, that is, which solution of the model equations is required (subsonic, critical or choked flow). When the type of flow has been determined, QUASC calculates the following parameters: entrance Mach number; mean friction factor; Reynolds number; distributions across the seal face of pressure, temperature, density, velocity, Mach number, and friction parameter $4f(L - x)/D$; mass and volume flow rates; Knudsen number, sealing dam force, center of pressure; and where appropriate, rotational Reynolds number, variables associated with power dissipation, and axial film stiffness.

Notes:

1. Automatic plotting of some of the output variables is an available option.
2. Input, internal calculations, and output are in either the International System of Units (SI) or the U.S. customary system.
3. The program is written in FORTRAN IV for use on an IBM 7094 II/7044 direct couple computer.
4. This computer program was used in designing the high speed, self-acting face-contact shaft seal described in NASA Tech Brief 72-10114.
5. Inquiries concerning this program should be directed to:

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